# INTRODUCTION TO ENVIRONMENTAL

# SCIENCE

UNIT 1

CHAPTER 1
Science and the Environment

CHAPTER 2
Tools of Environmental Science

CHAPTER 3
The Dynamic Earth

When they reach adulthood, amphibians, such as these unhatched salamanders, breathe through their skin, which makes them vulnerable to pollutants in their environment. Scientists closely monitor amphibian species to determine the effects of pollution on the world's ecosystems.

# Science and the Environment

CHAPTER 1



## PRE-READING ACTIVITY

FOLDNOTES

**Booklet**

Before you read this chapter, create the **FoldNote** entitled "Booklet" described in the Reading and Study Skills section of the Appendix. Label each page of the booklet with a main idea from the chapter. As you read the chapter, write what you learn about each main idea on the appropriate page of the booklet.

More than 2,700 m (9,000 ft) above sea level, a forest ecologist is studying biodiversity in a Costa Rican rain forest. To ascend to the treetops, he shoots an arrow over a branch and hauls himself up with the attached rope.

SECTION 1

# Understanding Our Environment

When someone mentions the term *environment,* some people think of a beautiful scene, such as a stream flowing through a wilderness area or a rain-forest canopy alive with blooming flowers and howling monkeys. You might not think of your backyard or neighborhood as part of your environment. In fact, the environment is everything around us. It includes the natural world as well as things produced by humans. But the environment is also more than what you can see—it is a complex web of relationships that connects us with the world we live in.

## What Is Environmental Science?

The students from Keene High School in **Figure 1** are searching the Ashuelot River in New Hampshire for dwarf wedge mussels. The mussels, which were once abundant in the river, are now in danger of disappearing completely—and the students want to know why. To find out more, the students test water samples from different parts of the river and conduct experiments. Could the problem be that sewage is contaminating the water? Or could fertilizer from a nearby golf course be causing algae in the river to grow rapidly and use up the oxygen that the mussels need to survive? Another possible explanation might be that a small dam on the river is disrupting the mussels' reproduction.

The students' efforts have been highly praised and widely recognized. Yet they hope for a more meaningful reward—the preservation of an endangered species. The students' work is just one example of a relatively new field—**environmental science,** the study of how humans interact with the environment.

## Objectives

- Define *environmental science,* and compare environmental science with ecology.
- List the five major fields of study that contribute to environmental science.
- Describe the major environmental effects of hunter-gatherers, the agricultural revolution, and the Industrial Revolution.
- Distinguish between renewable and nonrenewable resources.
- Classify environmental problems into three major categories.

## Key Terms

**environmental science**
**ecology**
**agriculture**
**natural resource**
**pollution**
**biodiversity**


**Figure 1** ▶ These students are counting the number of dwarf wedge mussels in part of the Ashuelot River. They hope that the data they collect will help preserve this endangered species.

**Connection to History**

**Rachel Carson** Alarmed by the increasing levels of pesticides and other chemicals in the environment, biologist Rachel Carson published *Silent Spring* in 1962. Carson imagined a spring morning that was silent because the birds and frogs were dead after being poisoned by pesticides. Carson's carefully researched book was enthusiastically received by the public and was read by many other scientists as well as policy makers and politicians. However, many people in the chemical industry saw *Silent Spring* as a threat to their pesticide sales and launched a $250,000 campaign to discredit Carson. Carson's research prevailed, although she died in 1964—unaware that the book she had written was instrumental in the birth of the modern environmental movement.

**The Goals of Environmental Science** One of the major goals of environmental science is to understand and solve environmental problems. To accomplish this goal, environmental scientists study two main types of interactions between humans and their environment. One area of study focuses on how we use natural resources, such as water and plants. The other area of study focuses on how our actions alter our environment. To study these interactions, environmental scientists must gather and analyze information from many different disciplines.

**Many Fields of Study** Environmental science is an interdisciplinary science, which means that it involves many fields of study. One important foundation of environmental science is ecology. **Ecology** is the study of how living things interact with each other and with their nonliving environment. For example, an ecologist might study the relationship between bees and the plants bees pollinate. However, an environmental scientist might investigate how the nesting behavior of bees is influenced by human activities such as the planting of suburban landscaping.

Many sciences other than ecology also contribute to environmental science. For example, chemistry helps us understand the nature of pollutants. Geology helps us model how pollutants travel underground. Botany and zoology can provide information needed to preserve species. Paleontology, the study of fossils, can help us understand how Earth's climate has changed in the past. Using such information about the past can help us predict how future climate changes could affect life on Earth. At any given time, an environmental scientist may use information provided by other sciences. **Figure 2** shows a few examples of disciplines that contribute to environmental science.

**Figure 2 ▶ Many Fields of Study**

▶ This marine biologist (right) is studying a marine mammal called a *manatee*.

▶ This ornithologist (above) is studying the nesting behavior of seabirds called *albatrosses*.

But studying the environment also involves studying human populations, so environmental scientists may use information from the social sciences, which include economics, law, politics, and geography. Social sciences can help us answer questions such as, How do cultural attitudes affect the ways that people use the U.S. park system? or How does human migration from rural to urban areas affect the local environment? **Table 1** lists some of the major fields of study that contribute to the study of environmental science.



**Table 1 ▼**

| Major Fields of Study That Contribute to Environmental Science | |
|---|---|
| **Biology** is the study of living organisms. | **Zoology** is the study of animals.<br>**Botany** is the study of plants.<br>**Microbiology** is the study of microorganisms.<br>**Ecology** is the study of how organisms interact with their environment and each other. |
| **Earth science** is the study of the Earth's nonliving systems and the planet as a whole. | **Geology** is the study of the Earth's surface, interior processes, and history.<br>**Paleontology** is the study of fossils and ancient life.<br>**Climatology** is the study of the Earth's atmosphere and climate.<br>**Hydrology** is the study of Earth's water resources. |
| **Physics** is the study of matter and energy. | **Engineering** is the science by which matter and energy are made useful to humans in structures, machines, and products. |
| **Chemistry** is the study of chemicals and their interactions. | **Biochemistry** is the study of the chemistry of living things.<br>**Geochemistry**, a branch of geology, is the study of the chemistry of materials such as rocks, soil, and water. |
| **Social sciences** are the study of human populations. | **Geography** is the study of the relationship between human populations and Earth's features.<br>**Anthropology** is the study of the interactions of the biological, cultural, geographical, and historical aspects of humankind.<br>**Sociology** is the study of human population dynamics and statistics. |

▶ This geologist is studying a volcano in Hawaii.

▶ This biologist is examining a plant that was grown in a lab from just a few cells.

## Ecofact

**The Fall of Troy** Environmental problems are nothing new. Nearly 3,000 years ago, the Greek poet Homer wrote about the ancient seaport of Troy, which was located beneath a wooded hillside. The Trojans cut down all the trees on the surrounding hills. Without trees to hold the soil in place, rain washed the soil into the harbor. So much silt accumulated in the harbor that large ships could not enter and Troy's economy collapsed. Today, the ruins of Troy are several miles from the sea.

## Scientists as Citizens, Citizens as Scientists

Governments, businesses, and cities recognize that studying our environment is vital to maintaining a healthy and productive society. Thus, environmental scientists are often asked to share their research with the world. **Figure 3** shows scientists at a press conference that was held after a meeting on climate change.

Often, the observations of nonscientists are the first step toward addressing an environmental problem. For example, when deformed frogs started appearing in lakes in Minnesota, middle school students noticed the problem first. Likewise, the students at Dublin Scioto High School in Ohio, shown in **Figure 3**, study box turtle habitats every year. The students want to find out how these endangered turtles live and what factors affect the turtles' nesting and hibernation sites. The students track the turtles, measure the atmospheric conditions, analyze soil samples, and map the movements of the small reptiles. Why do these efforts matter? They matter because the box turtle habitat is threatened. At the end of the year, students present their findings to city planners in hopes that the most sensitive turtle habitats will be protected.

**Figure 3 ▶ Environmental Science and Public Life** Scientists hold a press conference on climate change (above). Students (right) are studying the movements of box turtles.

## SECTION 1 Mid-Section Review

1. **Describe** the two main types of interactions that environmental scientists study. Give an example of each.
2. **Describe** the major fields of study that contribute to environmental science.
3. **Explain** why environmental science is an interdisciplinary science.

### CRITICAL THINKING

4. **Making Comparisons** What is the difference between environmental science and ecology?
5. **Making Inferences** Read the Ecofact. Propose a solution to prevent the environmental problems of the seaport of Troy described in the Ecofact.

READING SKILLS

## Our Environment Through Time

You may think that environmental change is a modern issue, but wherever humans have hunted, grown food, or settled, they have changed the environment. For example, the land where New York City now stands was once an area where Native Americans hunted game and gathered food, as shown in **Figure 4.** The environmental change that occurred on Manhattan Island over the last 300 years was immense, yet that period of time was just a "blink" in human history.

**Figure 4 ▶** Three hundred years ago Manhattan was a much different place. This painting shows an area where Native Americans hunted and fished.

**Hunter-Gatherers** For most of human history, people were *hunter-gatherers,* or people who obtain food by collecting plants and by hunting wild animals or scavenging their remains. Early hunter-gatherer groups were small, and they migrated from place to place as different types of food became available at different times of the year. Even today there are hunter-gatherer societies in the Amazon rain forests of South America and in New Guinea, as shown in **Figure 5.**

Hunter-gatherers affect their environment in many ways. For example, some Native American tribes hunted bison, which live in grasslands. The tribes set fires to burn the prairies and prevent the growth of trees. In this way, the tribes kept the prairies as open grassland where they could hunt bison. In addition, hunter-gatherer groups probably helped spread plants to areas where the plants did not originally grow.

In North America, a combination of rapid climate changes and overhunting by hunter-gatherers may have led to the disappearance of some large mammal species. These species include giant sloths, giant bison, mastodons, cave bears, and saber-toothed cats. Huge piles of bones have been found in places where ancient hunter-gatherers drove thousands of animals into pits and killed them.

**Graphic Organizer — Comparison Table**

Create the **Graphic Organizer** entitled "Comparison Table" described in the Appendix. Label the columns with "Hunter-Gatherers," "The Agricultural Revolution," and "The Industrial Revolution." Label the rows with "Characteristics" and "Effects on the Environment." Then, fill in the table with details about the characteristics and the effects on the environment of each historical period.

**Figure 5 ▶** This modern hunter-gatherer group lives in New Guinea, a tropical island off the north coast of Australia.

**Figure 6 ▶** This grass is thought to be a relative of the modern corn plant. Native Americans may have selectively bred a grass like this to produce corn.

**The Agricultural Revolution** Eventually many hunter-gatherer groups began to collect the seeds of the plants they gathered and to domesticate some of the animals in their environment. **Agriculture** is the practice of growing, breeding, and caring for plants and animals that are used for food, clothing, housing, transportation, and other purposes. The practice of agriculture started in many different parts of the world over 10,000 years ago. This change had such a dramatic impact on human societies and their environment that it is often called the *agricultural revolution.*

The agricultural revolution allowed human populations to grow at an unprecedented rate. An area of land can support up to 500 times as many people by farming as it can by hunting and gathering. As populations grew, they began to concentrate in smaller areas. These changes placed increased pressure on local environments.

The agricultural revolution also changed the food we eat. The plants we grow and eat today are descended from wild plants. During harvest season, farmers collected seeds from plants that exhibited the qualities they desired. The seeds of plants with large kernels or sweet and nutritious flesh were planted and harvested again. Over the course of many generations, the domesticated plants became very different from their wild ancestors. For example, the grass shown in **Figure 6** may be related to the grass that corn was bred from.

As grasslands, forests, and wetlands were replaced with farmland, habitat was destroyed. Slash-and-burn agriculture, shown in **Figure 7,** is one of the earliest ways that land was converted to farmland. Replacing forest with farmland on a large scale can cause soil loss, floods, and water shortages. In addition, much of this converted land was farmed poorly and is no longer fertile. The destruction of farmland had far-reaching environmental effects. For example, the early civilizations of the Tigris-Euphrates River basin collapsed, in part, because the overworked soil became waterlogged and contaminated by salts.

## FIELD ACTIVITY

**Germinating Corn** Many people do not realize how easy it is to grow corn plants from unpopped popcorn kernels. This ancient grass will sprout in a matter of days if it is watered frequently. Place a few popcorn kernels on a wet paper towel, and place the paper towel in a clear plastic cup so that the kernels are visible from the outside. Leave the cup on a windowsill for several days and water it frequently. As your plant grows, see if you can observe any grasslike features. Record your observations in your ***EcoLog.***

**Figure 7 ▶** For thousands of years humans have burned forests to create fields for agriculture. In this photo, a rain forest in Thailand is being cleared for farming.

**Figure 8 ▶** During much of the Industrial Revolution, few limits were placed on the air pollution caused by burning fossil fuels. Locomotives such as these are powered by burning coal.

**The Industrial Revolution** For almost 10,000 years the tools of human societies were powered mainly by humans or animals. However, this pattern changed dramatically in the middle of the 1700s with the Industrial Revolution. The Industrial Revolution involved a shift from energy sources such as animal muscle and running water, to fossil fuels, such as coal and oil. The increased use of fossil fuels and machines, such as the steam engines shown in **Figure 8**, changed society and greatly increased the efficiency of agriculture, industry, and transportation.

During the Industrial Revolution, the large-scale production of goods in factories became less expensive than the local production of handmade goods. On the farm, machinery further reduced the amount of land and human labor needed to produce food. As fewer people grew their own food, populations in urban areas steadily grew. Fossil fuels and motorized vehicles also allowed food and other goods to be transported cheaply across great distances.

**Improving Quality of Life** The Industrial Revolution introduced many positive changes. Inventions such as the light bulb greatly improved our quality of life. Agricultural productivity increased, and sanitation, nutrition, and medical care vastly improved. Yet with all of these advances, the Industrial Revolution introduced many new environmental problems. As the human population grew, many environmental problems such as pollution and habitat loss became more common.

In the 1900s, modern societies increasingly began to use artificial substances in place of raw animal and plant products. Plastics, artificial pesticides and fertilizers, and many other materials are the result of this change. While many of these products have made life easier, we are now beginning to understand some of the environmental problems they present. Much of environmental science is concerned with the problems associated with the Industrial Revolution.

**Figure 9 ▶** Modern communication technology, such as radios, TVs, and computers characterize the later stages of the Industrial Revolution.

**Figure 10 ▶** This photograph was taken in 1968 by the crew of *Apollo 8*. Photographs such as this helped people realize the uniqueness of the planet we share.

## Spaceship Earth

Earth has been compared to a ship traveling through space that cannot dispose of waste or take on new supplies as it travels. Earth is essentially a *closed system*—the only thing that enters Earth's atmosphere in large amounts is energy from the sun, and the only thing that leaves in large amounts is heat. A closed system of this sort has some potential problems. Some resources are limited, and as the population grows, the resources will be used more rapidly. In a closed system, there is also the chance that we will produce wastes more quickly than we can dispose of them.

Although the Earth can be thought of as a complete system, environmental problems can occur on different scales: local, regional, or global. For example, your community may be discussing where to build a new landfill, or local property owners may be arguing with environmentalists about the importance of a rare bird or insect. The drinking water in your region may be affected by a polluted river hundreds of miles away. Other environmental problems are global. For example, ozone-depleting chemicals released in Brazil may destroy the ozone layer that everyone on Earth depends on.

CASE STUDY

## Lake Washington: An Environmental Success Story

Seattle is located on a narrow strip of land between two large bodies of water. To the west is the Puget Sound, which is part of the Pacific Ocean, and to the east is Lake Washington, which is a deep freshwater lake. During the 1940s and early 1950s, cities on the east side of Lake Washington built 11 sewer systems that emptied into the lake. Unlike raw sewage, this sewage was treated and was not a threat to human health. So, people were surprised by research in 1955 showing that the treated sewage was threatening their lake. Scientists working in Dr. W. T. Edmondson's lab at the University of Washington found a bacterium, *Oscillatoria rubescens,* that had never been seen in the lake before.

Dr. Edmondson knew that in several lakes in Europe, pollution from sewage had been followed by the appearance of *O. rubescens*. A short time after, the lakes deteriorated severely and became cloudy, smelly, and unable to support fish. The scientists studying Lake Washington realized that they were seeing the beginning of this process.

About this same time, Seattle set up the Metropolitan Problems Advisory Committee, chaired by James Ellis. Dr. Edmondson wrote Ellis a letter that explained what could be expected in the future if action was not taken. The best solution to the problem seemed to be to pump the sewage around the lake and empty it deep into Puget Sound. Although this solution may seem like it would save one body of water by polluting another one, it was actually a good choice. Diluting the sewage in Puget Sound is less of an environmental problem than allowing it to build up in an enclosed lake.


Cities around the lake had to work together to connect their sewage plants to large lines that would carry the treated sewage to Puget Sound. Because there was no legal way for cities to connect plants

**Population Growth: A Local Pressure** One reason many environmental problems are so pressing today is that the agricultural revolution and the Industrial Revolution allowed the human population to grow much faster than it had ever grown before. The development of modern medicine and sanitation also helped increase the human population. As shown in **Figure 11,** the human population almost quadrupled during the 20th century. Producing enough food for such a large population has environmental consequences. In the past 50 years, nations have used vast amounts of resources to meet the world's need for food. Many of the environmental problems that affect us today such as habitat destruction and pesticide pollution are the result of feeding the world in the 20th century.

There are many different predictions of population growth for the future. But most scientists think that the human population will almost double in the 21st century before it begins to stabilize. We can expect that the pressure on the environment will continue to increase as the human population and its need for food and resources grows.

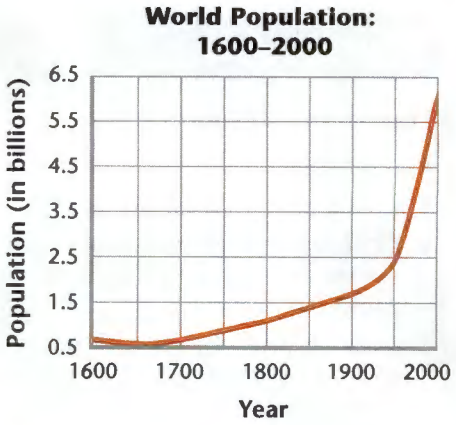
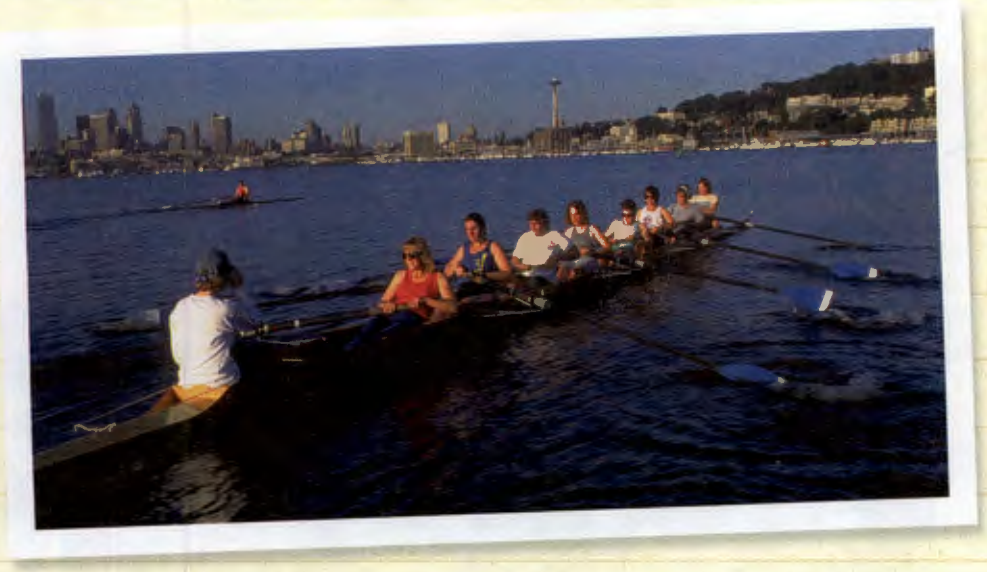



**Figure 11** ▶ The human population is now more than 10 times larger than the population of 400 years ago.



▶ Lake Washington is now clean enough for everyone to enjoy.

at the time, Ellis successfully worked for the passage of a bill in the state legislature that set up committees to handle projects of this kind. Newspaper articles and letters to the editor addressed the issue. Public forums and discussion groups were also held.

The first sewage plant was connected in 1963. Today, the lake is clearer than it has been since scientists began their studies of the lake in the 1930s. The story of Lake Washington is an example of how environmental science and public action work together to solve environmental problems. Science was essential to understanding a healthy lake ecosystem, to documenting changes that were beginning to cause problems, and to making predictions about what would happen if changes were made or if nothing was done. Engineers offered practical solutions to the problem of moving the sewage. Legislators and civic leaders addressed the legal problems. Volunteers, local media, and local activists provided public education and pressed to get the problem solved quickly. The clear, blue waters of Lake Washington stand as a monument to citizens' desires to live in a clean, healthy environment and to their ability to work together to make it happen.

## CRITICAL THINKING

**1. Analyzing Processes** Explain how each person and group played a crucial role in the cleanup of Lake Washington.

**2. Analyzing Relationships** How was the scientists' work similar to the work of the Keene High School students you read about in this section?

## QuickLAB

### Classifying Resources

**Procedure**

1. Create a table similar to Table 2.
2. Choose five objects in your classroom, such as a **pencil**, a **notebook**, or a **chair**.
3. Observe your objects closely, and list the resources that comprise them. For example, a pencil is made of wood, graphite, paint, aluminum, rubber, and pumice.
4. Classify the resources you have observed as nonrenewable or renewable.

**Analysis**

1. What percentage of the resources you observed are renewable? What percentage of the resources are nonrenewable?
2. Hypothesize the origin of three of the resources you observed. If time permits, research the origin of the resources you chose to find out if you were correct.

## What Are Our Main Environmental Problems?

You may feel as though the world has an unlimited variety of environmental problems. But we can generally group environmental problems into three categories: resource depletion, pollution, or loss of biodiversity.

**Resource Depletion** Any natural material that is used by humans is called a **natural resource.** Natural resources can be classified as renewable and nonrenewable as shown in **Table 2.** A *renewable resource* is a resource that can be replaced relatively quickly by natural processes. Fresh water, air, soil, trees, and crops are all resources that can be renewed. Energy from the sun is also a renewable resource. A *nonrenewable resource* is a resource that forms at a much slower rate than the rate that it is consumed. The most common nonrenewable resources are minerals and fossil fuels. Once the supply of a nonrenewable resource is used up, it may take millions of years to replenish it.

Resources are said to be *depleted* when a large fraction of the resource has been used up. **Figure 12** shows a mine where copper, a nonrenewable resource, is removed from the Earth's crust. Some renewable resources can also be depleted. For example, if trees are harvested faster than they can grow naturally in an area, deforestation will result.

**Pollution** One effect of the Industrial Revolution is that societies began to produce wastes faster than the wastes could be disposed of. These wastes accumulate in the environment and cause pollution. **Pollution** is an undesired change in air, water, or soil that adversely affects the health, survival, or activities of humans or

**Table 2 ▼**

| Renewable and Nonrenewable Resources | |
|---|---|
| **Renewable** | **Nonrenewable** |
| energy from the sun | metals such as iron, aluminum, and copper |
| water | nonmetallic materials such as salt, sand, and clay |
| wood | fossil fuels |
| soil | |
| air | |

**Figure 12 ▶** More than 12 million tons of copper have been mined from the Bingham mine in Utah. Once all of the copper that can be profitably extracted is used up, the copper in this mine will be depleted.

other organisms. Much of the pollution that troubles us today is produced by human activities. Air pollution in Mexico City, as shown in **Figure 13**, is dangerously high, mostly because of car exhaust.

There are two main types of pollutants. *Biodegradable pollutants* are pollutants that can be broken down by natural processes. They include materials such as human sewage or a stack of newspapers. Degradable pollutants are a problem only when they accumulate faster than they can be broken down. Pollutants that cannot be broken down by natural processes, such as mercury, lead, and some types of plastic, are called *nondegradable pollutants*. Because nondegradable pollutants do not break down easily, they can build up to dangerous levels in the environment.

**Figure 13 ▶** The problem of air pollution in Mexico City is compounded because the city is located in a valley that traps air pollutants.

**Loss of Biodiversity** The term biodiversity refers to the number and variety of species that live in an area. Earth has been home to hundreds of millions of species. Yet only a fraction of those species are alive today—the others are extinct. Extinction is a natural process, and several large-scale extinctions, or *mass extinctions*, have occurred throughout Earth's history. For example, at the end of the Permian period, 250 million years ago, as much as 95 percent of all species became extinct. So why should we be concerned about the modern extinction of an individual species such as the Tasmanian tiger shown in **Figure 14**?

The organisms that share the world with us can be considered natural resources. We depend on other organisms for food, for the oxygen we breathe, and for many other things. A species that is extinct is gone forever, so a species can be considered a nonrenewable resource. We have only limited information about how modern extinction rates compare with those of other periods in Earth's history. But many scientists think that if current rates of extinction continue, it may cause problems for human populations in the future. Many people also argue that all species have potential economic, ecological, scientific, aesthetic, and recreational value, so it is important to preserve them.

**Figure 14 ▶** The Tasmanian tiger may be the only mammal to become extinct in the past 200 years on the island of Tasmania. During the same period of time, on nearby Australia, as much as 50 percent of all mammals became extinct.

## SECTION 1 Review

1. **Explain** how hunter-gatherers affected the environment in which they lived.
2. **Describe** the major environmental effects of the agricultural revolution and the Industrial Revolution.
3. **Explain** how environmental problems can be local, regional, or global. Give one example of each.
4. **Identify** an example of a natural source of pollution.

### CRITICAL THINKING

5. **Analyzing Relationships** How did the Industrial Revolution affect human population growth?
6. **Making Inferences** Fossil fuels are said to be nonrenewable resources, yet they are produced by the Earth over millions of years. By what time frame are they considered nonrenewable? Write a paragraph that explains your answer. WRITING SKILLS

SECTION 2

# The Environment and Society

## Objectives

- Describe "The Tragedy of the Commons."
- Explain the law of supply and demand.
- List three differences between developed and developing countries.
- Explain what sustainability is, and describe why it is a goal of environmental science.

## Key Terms

**law of supply and demand**
**ecological footprint**
**sustainability**

When we think about environmental problems and how to solve them, we have to consider human societies, how they act, and why they do what they do. One way to think about society and the environment is to consider how a society uses common resources. A neighborhood park, for example, is a common resource that people share. On a larger scale, the open ocean is not owned by any nation, yet people from many countries use the ocean for fishing and for transporting goods. How do we decide how to share common resources? In 1968, ecologist Garrett Hardin published an essay titled "The Tragedy of the Commons," which addressed these questions and became the theoretical backbone of the environmental movement.

## "The Tragedy of the Commons"

In his essay, Hardin argued that the main difficulty in solving environmental problems is the conflict between the short-term interests of individuals and the long-term welfare of society. To illustrate his point, Hardin used the example of the *commons,* as shown in **Figure 15.** Commons were areas of land that belonged to a whole village. Anyone could graze cows or sheep on the commons. It was in the best short-term interest of an individual to put as many animals as possible on the commons. Individuals thought, If I don't use this resource, someone else will. And anyway, the harm my animals cause is too little to matter.

However, if too many animals grazed on the commons, the animals destroyed the grass. Then everyone suffered because no one could raise animals on the commons. Commons were eventually replaced by closed fields owned by individuals. Owners were careful not to put too many animals on their land, because overgrazing meant that fewer animals could be raised the next year. The point of Hardin's essay is that someone or some group has to

**Figure 15 ▶** Hardin observed that when land was held in common (left), individuals tended to graze as many animals as possible. Overgrazing led to the destruction of the land resources. When commons were replaced by enclosed fields owned by individuals (right), people tended to graze only the number of animals that the land could support.

take responsibility for maintaining a resource. If no one takes that responsibility, the resource can be overused and become depleted.

Earth's natural resources are our modern commons. Hardin thought that people would continue to deplete natural resources by acting in their own self-interest to the point of society's collapse. But Hardin did not consider the social nature of humans. Humans live in groups and depend on one another. In societies, we can solve environmental problems by planning, organizing, considering the scientific evidence, and proposing a solution. The solution may override the interests of individuals in the short term, but it improves the environment for everyone in the long term.

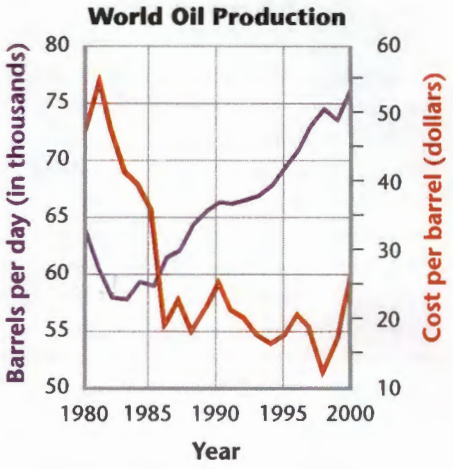
## Economics and the Environment

In addition to social pressures, economic forces influence how we use resources. Many of the topics you will explore later in this book are affected by economic considerations.

**Supply and Demand** One basic rule of economics is the **law of supply and demand,** which states that the greater the demand for a limited supply of something, the more that thing is worth. One example of this rule is shown in **Figure 16,** which illustrates the relationship between the production of oil and the price of oil over 20 years. Many environmental solutions have to take the relationship between supply and demand into account. For example, if the supply of oil decreases, we have three choices: pay the higher price, use less oil, or find new sources of energy.

**Costs and Benefits** The cost of environmental solutions can be high. To determine how much to spend to control air pollution, a community may perform a cost-benefit analysis. A *cost-benefit analysis* balances the cost of the action against the benefits one expects from it. The results of a cost-benefit analysis often depend on who is doing the analysis. To an industry, the cost of pollution control may outweigh the benefits, but to a nearby community, the benefits may be worth the high price. The cost of environmental regulations is often passed on to the consumer or the taxpayer. The consumer then has a choice—pay for the more expensive product that meets environmental regulations or seek out a cheaper product that may not have the same environmental safeguards.

**Risk Assessment** One of the costs of any action is the risk of an undesirable outcome. Cost-benefit analysis involves *risk assessment,* which is one tool that helps us create cost-effective ways to protect our health and the environment. To come up with an effective solution to an environmental problem, the public must perceive the risk accurately. This does not always happen. In one study, people were asked to assess the risk from various technologies. The public generally ranked nuclear power as the riskiest technology on the list, whereas experts ranked it 20th—less risky than riding a bicycle.




Source: U.S. Department of Energy.

**Figure 16 ▶** In general, when the production of oil declines, the price of a barrel of oil increases.

**MATHPRACTICE**

**Market Equilibrium**

In economics, the point where supply and demand are in balance is known as *market equilibrium.* In Figure 16, market equilibrium for oil was reached in 1986. What was the cost of a barrel of oil in that year? How many barrels of oil were produced in that year? By how much did the cost of a barrel of oil decline from 1981 to 1986?

**Geofact**

**Minerals of South Africa** The resources a country has are a result of geologic processes. South Africa, for example, has some of the most productive mineral deposits in the world. In fact, the country is nearly self-sufficient in the mineral resources that are important to modern industry. South Africa is the world's largest producer of gold, platinum, and chromium.

## Developed and Developing Countries

The decisions and actions of all people in the world affect our environment. But the unequal distribution of wealth and resources around the world influences the environmental problems that a society faces and the choices it can make. The United Nations generally classifies countries as either developed or developing. *Developed countries* have higher average incomes, slower population growth, diverse industrial economies, and stronger social support systems. They include the United States, Canada, Japan, and the countries of Western Europe. *Developing countries* have lower average incomes, simple and agriculture-based economies, and rapid population growth. In between are middle-income countries, such as Mexico, Brazil, and Malaysia.

## Population and Consumption

Almost all environmental problems can be traced back to two root causes. First, the human population in some areas is growing too quickly for the local environment to support. Second, people are using up, wasting, or polluting many natural resources faster than they can be renewed, replaced, or cleaned up.

**Local Population Pressures** When the population in an area grows rapidly, there may not be enough natural resources for everyone in the area to live a healthy, productive life. Often, as people struggle for survival in severely overpopulated regions, forests are stripped bare, topsoil is exhausted, and animals are driven to extinction. Malnutrition, starvation, and disease can be constant threats. Even though there are millions of people starving in developing countries, the human population tends to grow most rapidly in these countries. Food production, education, and job creation cannot keep pace with population growth, so each person gets fewer resources as time goes by. Of the 4.5 billion people in developing countries, fewer than half have access to enough food, safe drinking water, and proper sanitation.

**Figure 17** ▶ Developed and developing nations have different consumption patterns and different environmental problems. Both of these photos show food markets. What do you think the environmental problems of each consumption pattern are?

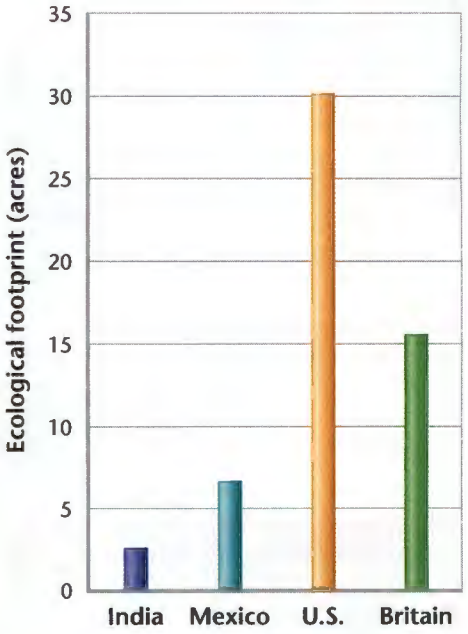
**Table 3 ▼**

| Indicators of Development for the United States, Japan, Mexico, and Indonesia | | | | | |
|---|---|---|---|---|---|
| | **Measurement** | **U.S.** | **Japan** | **Mexico** | **Indonesia** |
| **Health** | life expectancy in years | 77 | 81 | 71.5 | 68 |
| **Population growth** | per year | 0.8% | 0.2% | 1.7% | 1.8% |
| **Wealth** | gross national product per person | $29,240 | $32,350 | $3,840 | $640 |
| **Living space** | people per square mile | 78 | 829 | 133 | 319 |
| **Energy use** | per person per year (millions of Btu) | 351 | 168 | 59 | 18 |
| **Pollution** | carbon dioxide from fossil fuels per person per year (tons) | 20.4 | 9.3 | 3.5 | 2.2 |
| **Waste** | garbage produced per person per year (kg) | 720 | 400 | 300 | 43 |

**Consumption Trends** For many people in the wealthier part of the world, life is better than ever before. Pollution controls improve every year, and many environmental problems are being addressed. In addition, the population has stabilized or is growing slowly. But to support this quality of life, developed nations are using much more of Earth's resources than developing nations are. Developed nations use about 75 percent of the world's resources, even though they make up only about 20 percent of the world's population. This rate of consumption creates more waste and pollution per person than in developing countries, as shown in **Table 3.**

**Ecological Footprints** One way to express the differences in consumption between nations is as an ecological footprint, as shown in **Figure 18.** An **ecological footprint** shows the productive area of Earth needed to support one person in a particular country. It estimates the land used for crops, grazing, forest products, and housing. It also includes the ocean area used to harvest seafood and the forest area needed to absorb the air pollution caused by fossil fuels.

**Figure 18 ▶** An ecological footprint is a calculation of the amount of land and resources needed to support one person from a particular country. The ecological footprint of a person in a developed country is, on average, four times as large as the footprint of a person in a developing country.



## FIELD ACTIVITY

**Critical Thinking and the News**
Find a news article or watch a news broadcast about a current environmental issue. In your ***Ecolog,*** write down your initial reaction including your thoughts, feelings, and questions.

**Now, look or think again, and answer the following questions:**

- Did the report present different sides of the issue? Describe the sides.
- Did the report seem to favor one side over the other? How could you tell?
- Did the report use images, sounds, or words that made you feel a certain way?
- Did the report provide any facts that helped you form an opinion? Try to list the facts.
- Were sources of the facts provided? Did the sources seem reliable?
- Were the opinions of any expert scientists presented? Who were the scientists?
- Is there any information that was *not* provided that might be important? Give examples.
- When you think about the issue more, does your opinion change?

## Environmental Science in Context

As you have learned, environmental problems are complex. Simple solutions are rare, and they sometimes cause more damage than the original problem did. To complicate matters, in recent years, the environment has become a battleground for larger issues that affect human societies. For example, how do you balance the rights of individuals and property owners with the needs of society as a whole? Or, when economic or political refugees emigrate—legally or illegally—what can be done about the devastation they may cause to the local environment? How do human rights relate to the environment?

**Critical Thinking and the Environment** People on any side of an environmental issue may feel passionately about their cause, and they can distort information and mislead people about the issues. Research done by environmental scientists is often used to make political points or is misrepresented to support controversial viewpoints. In addition to the scientific data, the economic dimensions of an environmental issue can be oversimplified. To further complicate things, the media often sensationalizes environmental issues. So, as you make your own decisions about the environment, it is essential that you use your critical-thinking skills.

Learning to think critically about what you see in newspapers, on TV, and on the Internet will help you make informed decisions. As you explore environmental science further, you should remember a few things. First, be prepared to listen to many viewpoints. People have many different reasons for the opinions they form. Try to understand what those reasons are before reacting to their ideas. If you want your ideas to be heard, it is important that you listen to the opinions of others, as shown in **Figure 19.** Also, identify your own bias. How does it affect the way you interpret the issue?

**Figure 19 ▶** Anyone can express an opinion on environmental issues at state and local public hearings.

**internet connect**

**www.scilinks.org**
**Topic: Solving Environmental Problems**
**SciLinks code: HE4013**

SCILINKS. Maintained by the National Science Teachers Association

Second, investigate the source of the information you encounter. Ask yourself whether the authors have reason for bias. Also, question the conclusions that are drawn from data. Ask yourself if the data support the claims that are made. Be especially critical of information posted on the Internet—flashy graphics and persuasive text might be hiding a biased agenda. Finally, gather all the information you can before drawing a conclusion.

## A Sustainable World

Despite the differing points of view on the environment, most people support a key goal of environmental science: achieving sustainability. **Sustainability** is the condition in which human needs are met in such a way that a human population can survive indefinitely. A sustainable world is not an unchanging world—technology advances and human civilizations continue to be productive. But at the present time we live in a world that is far from sustainable. The standard of living in developed countries is high because those countries are using resources faster than they can be replaced.

The problems described in this chapter are not insurmountable. Achieving a sustainable world requires everyone's participation. If all parts of society—individual citizens, industry, and government—cooperate, we can move toward sustainability. For example, you read about how Seattle's Lake Washington is cleaner and healthier now than it was 30 years ago. Another example is the bald eagle, which was once on the brink of extinction. Today bald eagles are making a comeback, because of the efforts to preserve their habitat and to reduce pollution from the pesticide DDT.

Nevertheless, our environmental problems are significant and require careful attention and action. The 21st century will be a crucial time in human history, a time when we must find solutions that allow people on all parts of our planet to live in a clean, healthy environment and have the resources they need for a good life.

**Figure 20** ▶ These high school students are taking action to improve their environment. They are cleaning up trash that is clogging an urban creek.

**Connection to Astronomy**

**Another Earth?** If the environment on Earth changed drastically, would we have anywhere to go? There are no other planets in our solar system with an adequate range of temperatures, a breathable atmosphere, or the resources needed to sustain humans with our present technology. There may be other planets like Earth in the universe, but the closest planets we know of are in other solar systems that are light-years away.

## SECTION 2 Review

1. **Describe** three differences between developing and developed nations using the examples in Table 3. Would you classify Mexico as a developing nation? Explain your answer.
2. **Explain** why critical thinking is an important skill in environmental science.
3. **Explain** the law of supply and demand, and give an example of how it relates to the environment.

**CRITICAL THINKING**

4. **Applying Ideas** The law of supply and demand is a simplification of economic patterns. What other factors might affect the cost of a barrel of oil?
5. **Evaluating Ideas** Write a description of "The Tragedy of the Commons." Do you think that Hardin's essay is an accurate description of the relationship between individuals, society, and the environment? WRITING SKILLS

CHAPTER 1

# Highlights

## 1 Understanding Our Environment

### Key Terms

**environmental science,** 5
**ecology,** 6
**agriculture,** 10
**natural resource,** 14
**pollution,** 14
**biodiversity,** 15

### Main Ideas

- Environmental science is an interdisciplinary study of human interactions with the living and nonliving world. One important foundation of environmental science is the science of ecology.
- Environmental change has occurred throughout Earth's history.
- Hunter-gatherer societies cleared grassland by setting fires and may have contributed to the extinction of some large mammals.
- The agricultural revolution caused human population growth, habitat loss, soil erosion, and the domestication of plants and animals.
- The Industrial Revolution caused rapid human population growth and the increased use of fossil fuels. Most modern environmental problems began during the Industrial Revolution.
- The major environmental problems we face today are resource depletion, pollution, and loss of biodiversity.

## 2 The Environment and Society

**law of supply and demand,** 17
**ecological footprint,** 19
**sustainability,** 21

- "The Tragedy of the Commons" was an influential essay that described the relationship between the short-term interests of the individual and the long-term interests of society.
- The law of supply and demand states that when the demand for a product increases while the supply remains fixed, the cost of the product will increase.
- Environmental problems in developed countries tend to be related to consumption. In developing nations, the major environmental problems are related to population growth.
- Describing how sustainability can be achieved is a primary goal of environmental science.

# CHAPTER 1 Review

## Using Key Terms

Use each of the following terms in a separate sentence.

1. *agriculture*
2. *natural resource*
3. *pollution*
4. *ecological footprint*
5. *sustainability*

Use the correct key term to complete each of the following sentences.

6. The_____ Revolution was characterized by a shift from human and animal power to fossil fuels.
7. Resources that can theoretically last forever are called _____ resources.
8. _____ is a term that describes the number and variety of species that live in an area.

### STUDY TIP

**Root Words** As you study it may be helpful to learn the meaning of important root words. You can find these roots in most dictionaries. For example, *hydro-* means "water." Once you learn the meaning of this root, you can learn the meanings of words such as *hydrothermal, hydrologist, hydropower,* and *hydrophobic.*

## Understanding Key Ideas

9. An important effect that hunter-gatherer societies may have had on the environment was
   **a.** soil erosion.
   **b.** extinction.
   **c.** air pollution.
   **d.** All of the above
10. An important effect of the agricultural revolution was
    **a.** soil erosion.
    **b.** habitat destruction.
    **c.** plant and animal domestication.
    **d.** All of the above
11. Which of the following does *not* describe an effect of the Industrial Revolution?
    **a.** Fossil fuels became important energy sources.
    **b.** The amount of land and labor needed to produce food increased.
    **c.** Artificial substances replaced some animal and plant products.
    **d.** Machines replaced human muscle and animal power.
12. Pollutants that are not broken down by natural processes are
    **a.** nonrenewable.
    **b.** nondegradable.
    **c.** biodegradable.
    **d.** Both (a) and (c)
13. All of the following are renewable resources *except*
    **a.** energy from the sun.
    **b.** minerals.
    **c.** crops.
    **d.** fresh water.
14. In his essay, "The Tragedy of the Commons," one factor that Garrett Hardin failed to consider was
    **a.** the destruction of natural resources.
    **b.** human self-interest.
    **c.** the social nature of humans.
    **d.** None of the above
15. The term used to describe the productive area of Earth needed to support the lifestyle of one person in a particular country is called
    **a.** supply and demand.
    **b.** the ecological footprint.
    **c.** the consumption crisis.
    **d.** sustainability.

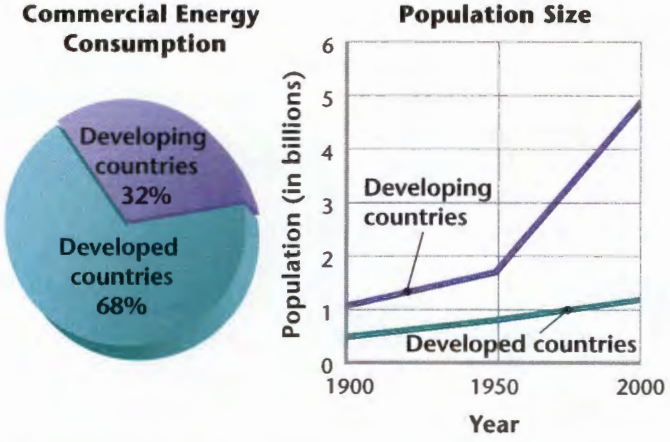
# CHAPTER 1 Review

## Short Answer

16. Give an example of how environmental science might involve geology and chemistry.
17. Can biodegradable pollutants cause environmental problems? Explain your answer.
18. In what ways are today's environmental resources like the commons described in the essay "The Tragedy of the Commons"?
19. How could environmental concerns conflict with your desire to improve your standard of living?
20. If you were evaluating the claims made on a Web site that discusses environmental issues what types of information would you look for?
21. Can species be considered natural resources? Explain your answer.

## Interpreting Graphics

The graphs below show the difference in energy consumption and population size in developed and developing countries. Use the graphs to answer questions 22–24.




22. Describe the differences in energy consumption and population growth between developed and developing countries.
23. Do you think that the percentage of commercial energy consumed by developing countries will increase or decrease? Explain your answer.
24. Why is information on energy consumption represented in a pie graph, while population size is shown in a line graph?

## Concept Mapping

25. Use the following terms to create a concept map: *geology, biology, ecology, environmental science, chemistry, geography,* and *social sciences.*

## Critical Thinking

26. **Analyzing Ideas** Are humans part of the environment? Explain your answer.
27. **Drawing Conclusions** Why do you think that fossil fuels were not widely used until the Industrial Revolution? Write a paragraph that describes your thoughts. WRITING SKILLS
28. **Evaluating Assumptions** Once the sun exhausts its fuel and burns itself out, it cannot be replaced. So why is the sun considered a renewable resource?
29. **Evaluating Assumptions** Read the description of the Industrial Revolution. Were all the effects of the Industrial Revolution negative? Explain your answer. READING SKILLS

## Cross-Disciplinary Connection

30. **Demographics** Obtain the 1985 and 2000 census reports for your town or city. Look for changes in demographic characteristics, such as population size, income, and age. Make a bar graph that compares some of the characteristics you chose. How does your city or town compare with national trends? What might be some of the environmental implications of these trends?

## Portfolio Project

31. **Make a Diagram** Many resources can be traced to energy from the sun. For example, plants living in swamps millions of years ago used energy from the sun to grow. Over time, some of these plants became coal deposits. When we burn coal today, we are using energy that radiated from the sun millions of years ago. Choose a resource, and create a diagram that traces the resource back to energy from the sun.

## MATH SKILLS

Use the table below to answer questions 32–34.

| | U.S. | Japan | Indonesia |
|---|---|---|---|
| People per square mile | 78 | 829 | 319 |
| Garbage produced per person per year | 720 kg | 400 kg | 43 kg |

32. **Analyzing Data** Make a bar graph that compares the garbage produced per person per year in each country.
33. **Making Calculations** Calculate how much garbage is produced each year per square mile of each country listed in the table.
34. **Evaluating Data** Use the information in the table to evaluate the validity of the following statement: In countries where population density is high, more garbage is produced per person.

## WRITING SKILLS

35. **Communicating Main Ideas** Briefly describe the relationship between humans and the environment through history.
36. **Writing Persuasively** Write a persuasive essay explaining the importance of science in a debate about an environmental issue.
37. **Outlining Topics** Write a one-page outline that describes population and consumption in the developing and developed world.

## STANDARDIZED TEST PREP

For extra practice with questions formatted to represent the standardized test you may be asked to take at the end of your school year, turn to the sample test for this chapter in the Appendix.

## READING SKILLS

**Read the passage below, and then answer the questions that follow.**

Think about what you did this morning. From the moment you got up, you were making decisions and acting in ways that affect the environment. The clothes you are wearing, for example, might be made of cotton. Several years ago the fibers of cotton in your shirt might have sprouted as seedlings in Egypt or Arizona. The cotton seedlings were probably irrigated with water diverted from a nearby river or lake. Chemicals such as pesticides, herbicides, and fertilizers helped the seedlings grow into plants. Furthermore, the metal in the machines that harvested the cotton was mined from the Earth's crust. In addition, the vehicles that brought the shirt to the store where you bought it were powered by fossil fuels. Fossil fuels came from the bodies of tiny sea creatures that lived millions of years ago. All of these connections can make environmental science a complex and interesting field.

1. According to the passage, which of the following conclusions is true?
   - **a.** Decisions we make in everyday life do not affect our environment.
   - **b.** Cotton comes from minerals in the Earth's crust.
   - **c.** Many different things in the environment are connected and interrelated.
   - **d.** There is no connection between the resources needed to grow a field of cotton and a cotton shirt.
2. Which of the following statements best describes the meaning of the term *irrigation*?
   - **a.** Irrigation is a connection between living things in the environment.
   - **b.** Irrigation is the artificial process by which water is supplied to plants.
   - **c.** Irrigation is the process of diverting water from a stream or lake.
   - **d.** Irrigation is the process by which cotton seedlings grow into plants.

CHAPTER 1

# Exploration Lab: FIELD ACTIVITY

## Objectives

- **Survey** an area of land and determine the land's physical features and the types of organisms that live there.
- USING SCIENTIFIC METHODS **Identify** possible relationships between the organisms that live in the area of land you surveyed.

## Materials

**hand lens**
**markers or felt-tip pens of several different colors**
**notebook**
**pen or pencil**
**poster board**
**stakes, (4)**
**string, about 50 m**
**tape measure or metric ruler**

*optional materials:* **field guides to insects or plants**

▶ **Marking a Site** Use stakes and string to mark a site that you will observe in detail.

## What's in an Ecosystem?

How well do you know the environment around your home or school? You may walk through it every day without noticing most of the living things it contains or thinking about how they survive. Ecologists, on the other hand, observe organisms and seek to understand how ecosystems work. In this lab, you will play the role of an ecologist by closely observing part of your environment.

## Procedure

1. Use a tape measure or meter stick to measure a 10 m × 10 m site to study. Place one stake at each corner of the site. Loop the string around each stake, and run the string from one stake to the next to form boundaries for the site.
2. Survey the site, and then prepare a site map of the physical features of the area on the poster board. For example, show the location of streams, sidewalks, trails, or large rocks, and indicate the direction of any noticeable slope.
3. Create a set of symbols to represent the organisms at your site. For example, you might use green triangles to represent trees, blue circles to represent insects, or brown squares to represent animal burrows or nests. At the bottom or side of the poster board, make a key for your symbols.
4. Draw your symbols on the map to show the location and relative abundance of each type of organism. If there is not enough space on your map to indicate the specific kinds of plants and animals you observed, record them in your notebook.
5. In your notebook, record any observations of organisms in their environment. For example, note insects feeding on plants or seeking shelter under rocks. Also describe the physical characteristics of your study area. Consider the following characteristics:
   a. **Sunlight Exposure** How much of the area is exposed to sunlight?
   b. **Soil** Is the soil mostly sand, silt, clay, or organic matter?
   c. **Rain** When was the last rain recorded for this area? How much rain was received?
   d. **Maintenance** Is the area maintained? If so, interview the person who maintains it and find out how often the site is watered, fertilized, treated with pesticides, and mowed.
   e. **Water Drainage** Is the area well drained, or does it have pools of water?
   f. **Vegetation Cover** How much of the soil is covered with vegetation? How much of the soil is exposed?
6. After completing these observations, identify a 2 m × 2 m area that you would like to study in more detail. Stake out this area, and wrap the string around the stakes.

7. Use your hand lens to inspect the area, and record the insects you see. Be careful not to disturb the soil or the organisms. Then record the types of insects and plants you see.
8. Collect a small sample of soil, and observe it with your hand lens. Record a description of the soil and the organisms that live in it.

## Analysis

1. **Organizing Data** Return to the classroom, and display your site map. Use your site map, your classmates' site maps, and your notes, to answer the following questions. Write your answers in your notebook.
2. **Analyzing Data** Write one paragraph that describes the 10 m × 10 m site you studied.
3. **Analyzing Data** Describe the 2 m × 2 m site you studied. Is this site characteristic of the larger site?

▶ **Site Maps** Your site map should be as detailed as possible, and it should include a legend.


## Conclusions

4. **Interpreting Conclusions** What are the differences between the areas that your classmates studied? Do different plants and animals live in different areas?
5. **Making Predictions** As the seasons change, the types of organisms that live in the area you studied may also change. Predict how your area might change in a different season or if a fire or flood occurred. If possible, return to the site at different times throughout the year and record your observations.

## Extension

1. **Asking Questions** Based on what you have learned, think of a question that explores how the components of the area you observed interact with each other. For example, you might want to consider the influence of humans on the site; study a particular predator/prey relationship; or explore the effects of physical features, such as water or sunlight, on the growth or behavior of organisms. Write a description of how you would investigate this topic. WRITING SKILLS

# Making a difference

## CHICKEN OF THE TREES

In the stillness of predawn, the air warms over the Carara Biological Preserve in Costa Rica. Several thousand eggs in sun-heated incubators just below the surface of the Earth stir in response. Within these eggs are tiny iguanas—lizards that will eventually emerge, grow to a length of 1.5 m to 2.0 m (5 ft to 6.5 ft), and weigh up to 6 kg (13 lb).

What's going on here? Well, these giant lizards are being raised so that they can be released into the rain forest. It's part of a project led by German-born scientist Dr. Dagmar Werner. Her goal is to help restore an iguana population that has been severely reduced in the past several decades.

The lizard has suffered from the effects of hunting, pollution, and habitat destruction by people who clear the rain forest for farming. Prime iguana habitat is at the edge of the forest—where a combination of open areas, scrub, and trees occur. Historically, these areas are the type of habitat that humans most often destroy when converting forestland to farmland. People cut down the forest at its edges—which just happens to be prime habitat for iguanas and other plants and animals.

### Back at the Iguana Ranch

Dr. Werner's "iguana ranch" preserve has artificial nests where females can lay their eggs in a predator-free environment. After they hatch, the young lizards are placed in a temperature- and humidity-controlled incubator and given a special diet. As a result, the iguanas grow faster and stronger and are better protected from predators than their noncaptive counterparts.

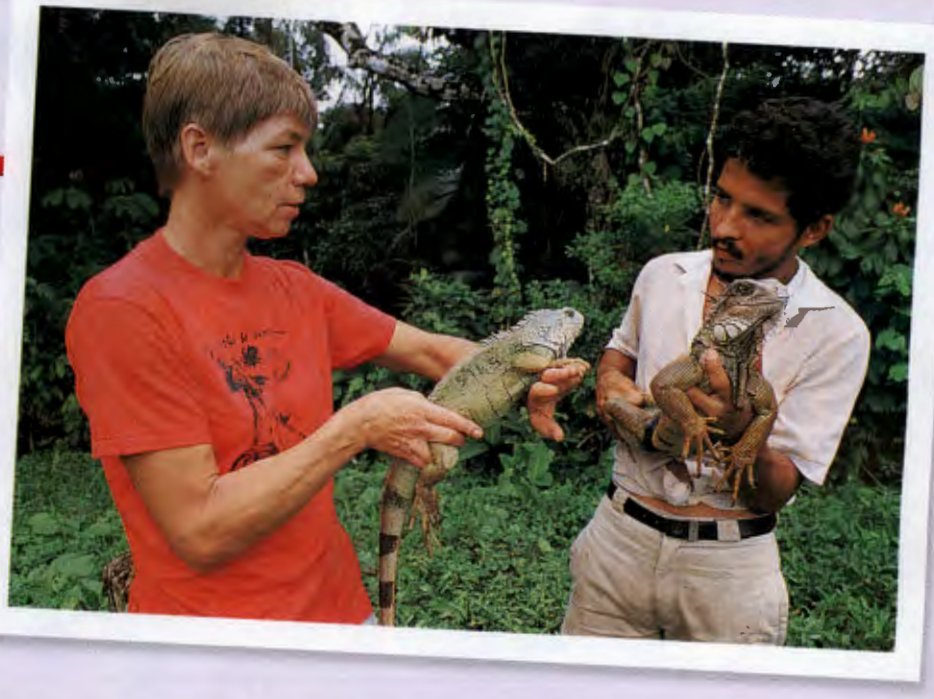
In the first five years of her project, more than 80,000 iguanas were released into the wild. Ordinarily, less than 2 percent of all iguanas survive to adulthood in the wild, but Dr. Werner's iguanas have a 77 percent survival rate. Dr. Werner knows this because after she releases the iguanas into the rain forest, the lizards are tracked and monitored to determine whether they have successfully adapted to life in the wild.

### Passing It On

Since the 1980s, Dr. Werner has improved the iguanas' chances of survival by breeding them and releasing thousands of young iguanas into the wild. But Dr. Werner soon realized that this effort was not enough, so she began training other people to do the same.

Because she knew there was no time to lose, Dr. Werner took an immediate and drastic approach to solving the problem. She combined her captive-breeding program at the preserve with an education program that shows farmers that there is more than one way to make a profit from the rain forest. Instead

▶ These are iguanas at the Carara Biological Preserve in Costa Rica.



▶ Dr. Werner and an associate discuss how the iguana can be farmed.

of raising cattle (and cutting down rain forest to do so), she encourages local farmers to raise iguanas, which can be released into the wild or sold for food. Known as the "chicken of the trees," this lizard has been a favored source of meat among native rain-forest inhabitants for thousands of years.

Not only do farmers profit from the sale of iguana meat, they also produce iguana leather and other handicrafts from the lizard.

## Fundación Pro Iguana Verde

With Dr. Werner's methods, farmers can release many iguanas into the wild and earn a good living. But convincing farmers to use her methods hasn't been easy. According to Dr. Werner, "Many locals have never thought of wild animals as creatures that must be protected in order to survive. That's why so many go extinct." To get her message across, Dr. Werner has established the Fundación Pro Iguana Verde (the Green Iguana Foundation). This organization sponsors festivals and education seminars in local communities. These activities promote the traditional appeal of the iguana, increase civic pride in the animal, and heighten awareness about the iguana's economic importance.

By demonstrating that the needs of all concerned parties can be met when attempting to save an endangered species, Dr. Werner has revolutionized the concepts of species preservation and economic development. This hard-working scientist has hit upon a solution that may encourage farmers throughout Central America to "have their lizards and eat them too."

▶ Dr. Werner has established an innovative way to raise the number of iguanas living in the wild.

### What Do You Think?

How does Dr. Werner's project protect iguanas and help local farmers too? Why do you think that she trains farmers to raise and value iguanas—what could her larger goal be? Can you think of a similar project that would be suitable for your area?